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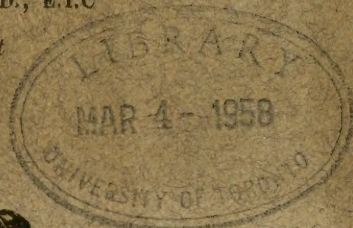
Memoirs of the Department of Agriculture in India

EVAPORATION FROM A PLAIN WATER SURFACE

BY

J. WALTER LEATHER, PH.D., E.I.C

Imperial Agricultural Chemist



AGRICULTURAL RESEARCH INSTITUTE, PUSA

PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA

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DEPARTMENT OF AGRICULTURE
IN INDIA

CHEMICAL SERIES

Volume III



AGRICULTURAL RESEARCH INSTITUTE, PUSA

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Vol. III, No. 1

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EVAPORATION FROM A PLAIN WATER SURFACE

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J. WALTER LEATHER, Ph.D., F.I.C

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MEMORANDUM OF THE DEPARTMENT OF AGRICULTURE IN INDIA

ANALYSIS OF THE WATER SUPPLY

CALCUTTA :

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EVAPORATION FROM A PLAIN WATER SURFACE.

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DR. J. WALTER LEATHER, Ph.D., F.I.C.,

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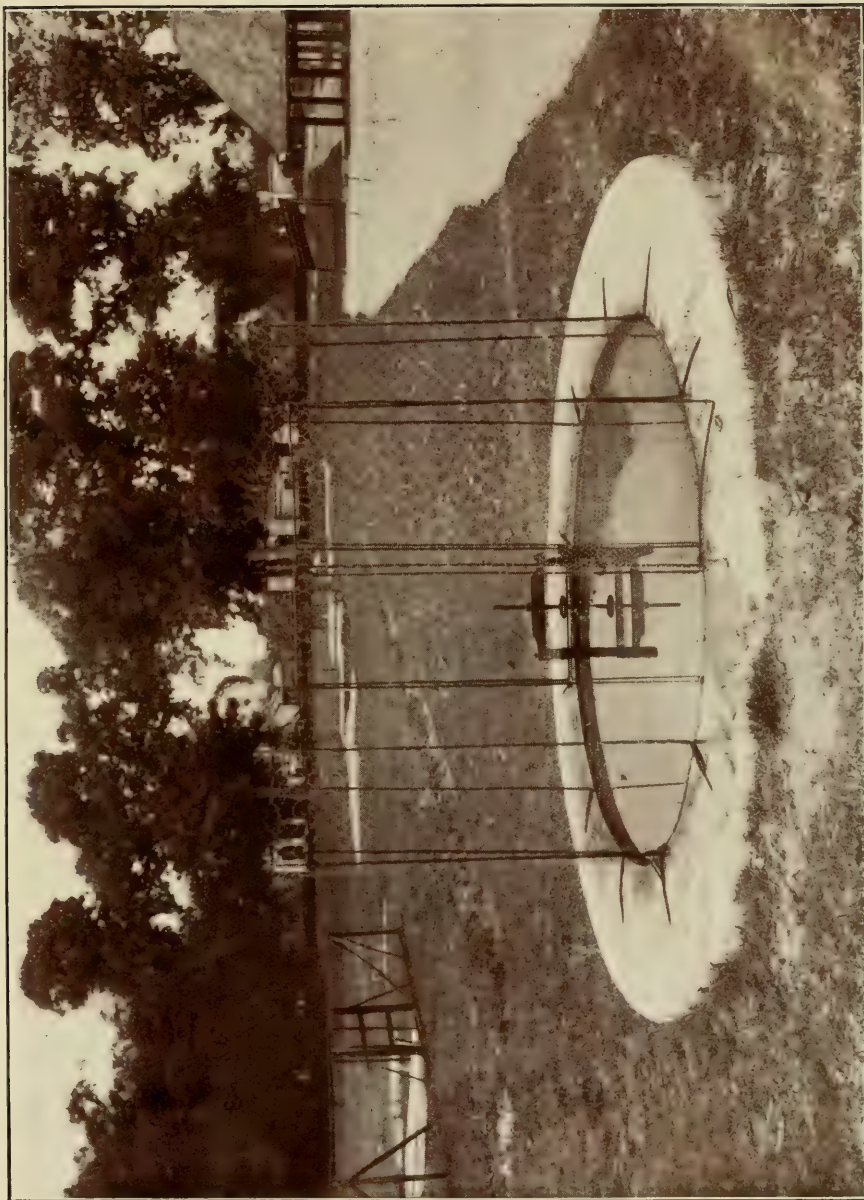
IN connection with the records of the water requirements of crops which have been maintained here during the past few years, information as to the amount of water which evaporates from a plain water surface in India was desired. Enquiry showed, however, that the amount of such information was very limited. The Meteorological Department was able to supply data from the Madras Observatory (see page 15). Another record obtained from Roorkee was obviously inexact because the evaporation found during the hot months was not greater than for the cold weather. Other records were being maintained by the Irrigation Department, Punjab (see page 15), but these were not then available, and in any case would be of doubtful service for Behar.

The Tank.—It was accordingly decided to maintain a record at Pusa. For this purpose a cement-lined masonry tank was constructed of the following dimensions: diameter 6 ft. 6 in. by depth 5 ft. It was situated in a field, but was not as free from neighbouring trees as might be desired; there is a line of bamboos about 110 ft. on the west side, and an avenue of teaks on the south-east side is 100 ft. distant. This position of the tank was dictated by the fact that difficulties would arise in preventing such a tank from being interfered with if it were placed in any large open field, whereas in the compound of the pot-culture house the necessary protection was available.

The Evaporimeter.—The first instrument employed for maintaining the record was a self-recording evaporimeter made by one of the larger meteorological instrument makers, and consisted essentially of two parts: (a) a float which was suspended by a metal cord from a pulley which actuated a pen through toothed gearing, and (b) a rotating drum which carried the paper chart on which the curve would be drawn. The instrument proved defective for two reasons. First, a part of the mechanism was exposed to the outside atmosphere, and dust rapidly collected in the toothed gearing. It would be quite impossible to prevent the dust of the Indian atmosphere outside from obtaining access to such instruments however carefully enclosed they might be. The gearing became gradually blocked, which affected the pen, and the record accordingly was soon defective. The second defect lay in the fact that the scale reading on the chart only indicated 2 mm. for each line, and the evaporation could only be estimated approximately to the nearest .5 mm. As will be subsequently seen, it is necessary to be able to estimate the evaporation to .1 mm. per 24 hours in order to demonstrate properly the magnitude of this quantity.

This experience with an otherwise well constructed self-recording evaporimeter led me to reject any further attempts in the use of such instruments. At this time a description was published in "Punjab Irrigation Branch Paper" No. 11, Part I A, page 44, of the instrument which was being employed in the Punjab for their records, and the Chief Engineer very kindly supplied me with one of these. It consists of an iron rod which stands vertically on an iron foot in the tank. The rod has a screw thread and on this a small hand wheel works. There is also a pointer which travels along the rod in a groove and this travels upwards and downwards with the hand wheel. Thus it can be brought carefully into contact with the water surface and its position in respect of some zero point ascertained. For the Pusa tank this instrument was slightly altered; the foot with a part of the rod was cut off, and the portion carrying the pointer was fixed, as seen in the Plate I, to an iron frame over the water

PLATE I.



EVAPORIMETER AND TANK.

surface. Also the small hand wheel was divided into tenths on the periphery. In order to ascertain the position of the water surface, it is only necessary to screw the pointer carefully down to the water surface, and then to count the revolutions from this position back to the zero. For the zero point a small iron stud was fixed into the pointer groove. Each revolution of the hand wheel = .298 cm., and since the position of the water surface can be read to $\frac{1}{20}$ part of this (= .015 cm.), the instrument forms, in so far, a very exact measure of its position.

Protection of the tank.—At first the tank was left quite exposed, but in 1910 it was decided to surround it with a guard of wire netting. A ring of dry earth placed round the tank showed that animals, presumably jackals, came at night and drank water from the tank. The number of such was not large. For example, the following counts were made :—

On 26th May 1910—foot prints of two or three jackals.

On 27th May 1910—foot prints of two jackals.

On 28th May 1910—none.

On 29th May 1910—foot prints of one large and one small jackal.

On 30th May 1910—foot prints of one jackal.

On 31st May 1910—foot prints of one jackal.

On 1st June 1910—none.

On 2nd June 1910—foot prints of one jackal.

On 3rd June 1910—foot prints of one or two jackals.

On 4th June 1910—none.

The quantity of water which was being thus taken was not sufficient to materially affect the record, but since it was a measurable error, wire netting was fixed on the rim. The netting is 4 ft. high and of 2 in. mesh, and in addition a second strip of $\frac{1}{2}$ in. mesh by 12 in. high was fixed at the bottom. The former prevents any large animals from drinking whilst the latter keeps off small ones. The mesh was as large as possible so as to interfere with the wind as little as might be.

Percolation through walls of tank.—The loss of water due to percolation through the sides and bottom of the tank has

been determined several times. Since it was cement lined, the anticipation was that it would prove only fairly water-proof. The first test was made by covering the top of the tank with 1 in. planks which fitted fairly well together, and whilst not entirely excluding evaporation, would nevertheless reduce it so much that an estimate of the amount of percolation would be possible. An aperture was left for the pointer to pass on to the water surface. This mode of stopping evaporation proved highly defective. The timber became wet and warped badly and most irregular readings were obtained. Another method which has proved entirely satisfactory is to pour a layer of mustard oil about .3 cm. thick over the water surface. Since vegetable oil is substantially not volatile at ordinary temperatures, it follows that any fall in the surface would be occasioned only by percolation of the water through the sides and bottom of the tank. Tests were made in 1911 and in 1913. The following are the records:—

1911.				1913.			
Gauge reading.				Gauge reading.			
November 13th	...	9.2	February 17th	...	2.7		
" 14th	...	9.2	" 18th	...	2.7		
" 15th	...	9.25	" 19th	...	2.7		
" 16th	...	9.25	" 20th	...	2.7		
" 17th	...	9.25	" 21st	...	2.7		
" 18th	...	9.25					
" 19th	...	9.25					

The variation is therefore less than $1/20$ revolution of the hand wheel, that is, $< .015$ cm. in 5 days and is therefore negligibly small.

Rim of tank.—One defect in the construction of the tank should be noticed. The rim is horizontal. As a consequence any rain which falls may in part run into the tank, in part away from it. This could have been obviated by giving the rim a slope, either inwards or outwards, but this was not done because in either case air movements over the water surface would be interfered with. Constructed as it is the water surface is maintained within about 1" of the surrounding ground level. Thus

the water surface during dry weather has been exposed more normally than if a bevelled rim has surrounded it, but any rainfall renders the estimation of the evaporation impossible.

Mode of maintaining the record.—In using the instrument the procedure has been to read the position of the pointer at 8 A.M. daily; next to remove any leaves which may have blown into the tank; then to add sufficient water to bring the surface to within about 1" of the rim and again to record its level; the reading of the gauge at 8 A.M. the next morning before adding water, yields, when subtracted from that of the previous day (after addition of water), the amount of water which has evaporated in 24 hours. The actual record is naturally in terms of revolutions of the hand wheel in the first place, which is then converted into millimetres.

Data obtained.—Since there is so little published information on the subject of evaporation in India, the complete data for the years 1911 and 1912 are set out as Statement I. From these, averages have been taken for (a) a monthly estimate of the daily evaporation, Statement II, and (b) the curves which are published as Charts I & II.

Recently the monthly averages of evaporation at Lyallpur in the Punjab have been published in "Irrigation Branch Paper" II-C, and these are added to Statement II. As published in Paper II-C, the data are expressed in terms of feet per hour, and this form has been converted into mm. per 24 hours so as to be comparable with our data. Also the means of the Madras record, for the years 1898-1903, have been converted from inches per day to mm. per 24 hours and added to Statement II.

An examination of the columns in this statement shows that the rate of evaporation during the cold weather months is much the same at Pusa and at Lyallpur, but that it is much higher at Lyallpur throughout the six hot months from May to October. At Madras there is a much smaller annual variation as might be expected. At Pusa during the hottest months the rate is three times that of the coldest; at Lyallpur it is five times; but at Madras the rate does not rise to twice.

CHART I.

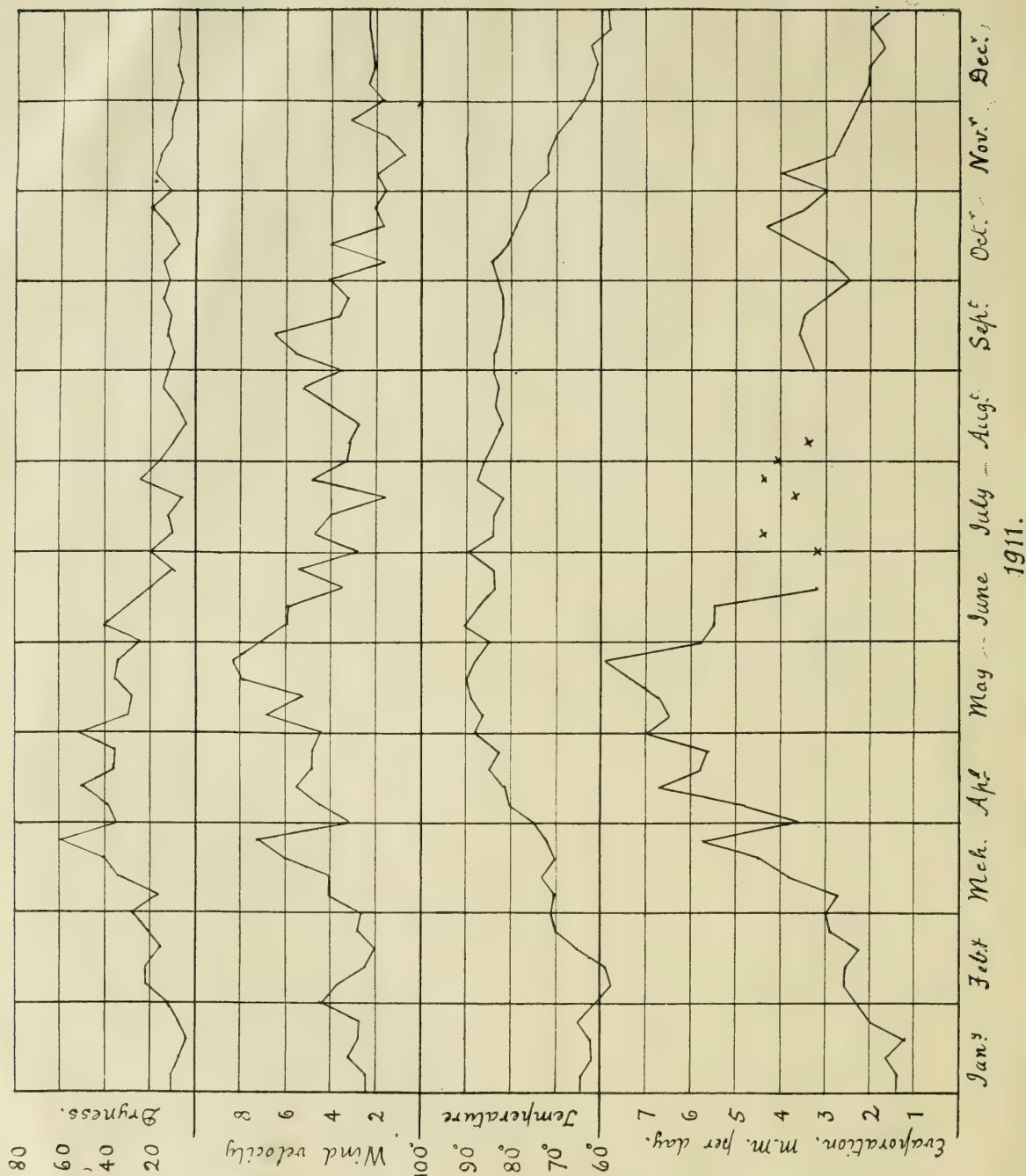
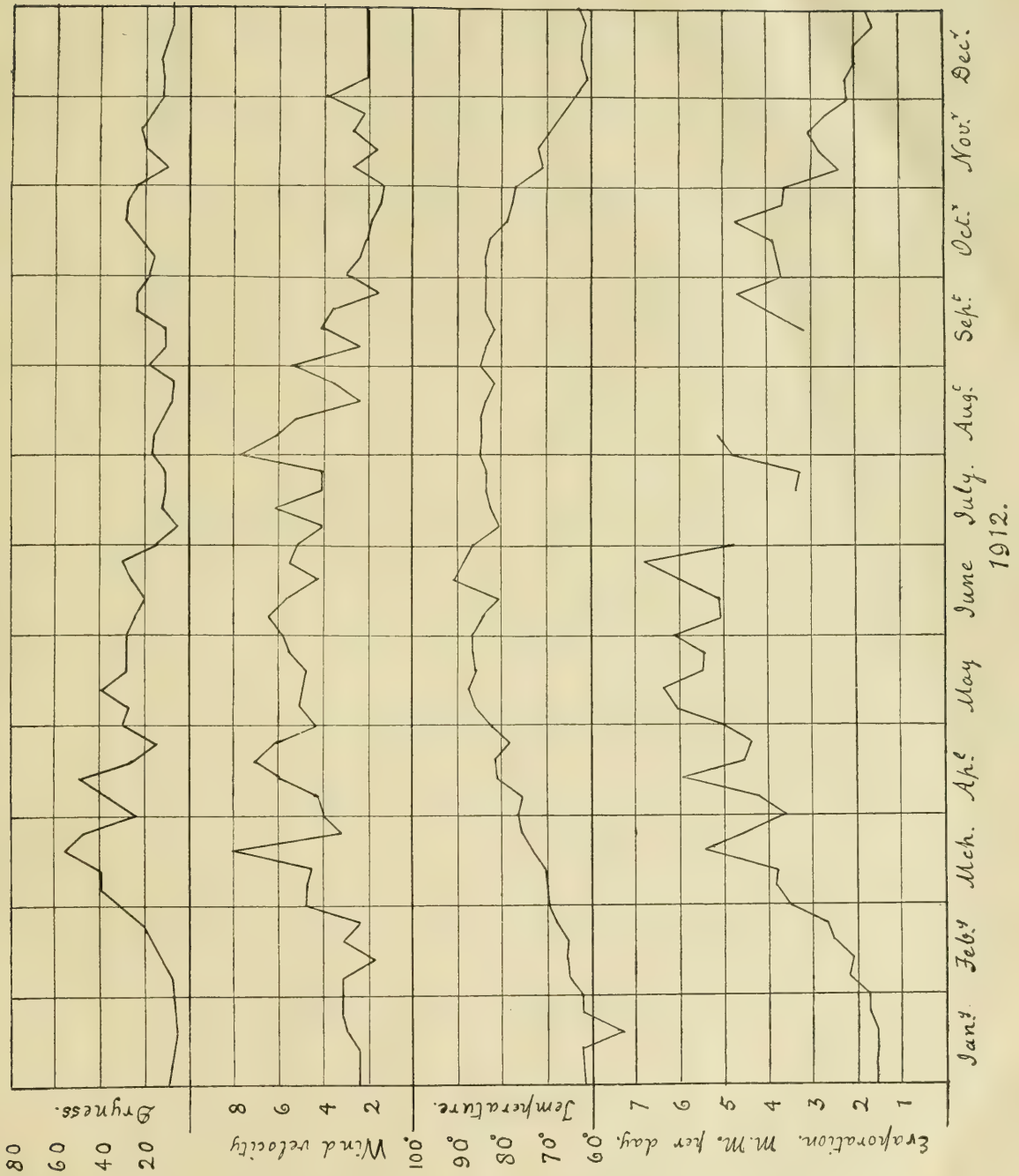


CHART II.



STATEMENT I.

Evaporation from a plain water surface at the Agricultural Research Institute, Pusa (1911).

Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	Dec.
1st	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
2nd	1.8	2.4	2.1	3.3	6.6	3.3	4.8	rainy day	rainy day	2.4	3.3	2.1
3rd	1.2	2.7	rainy day	3.6	6.0	5.7	rainy day	3.6	"	2.4	3.6	1.5
4th	1.2	3.3	2.1	4.2	4.8	6.9	4.5	rainy day	"	3.0	4.5	2.1
5th	1.5	2.1	2.7	4.8	9.8	6.3	3.9	"	"	3.9	5.7	1.8
6th	1.8	2.4	3.3	6.3	6.0	rainy day	rainy day	3.3	"	rainy day	3.6	2.1
7th	2.1	2.7	3.6	6.9	6.6	"	"	rainy day	4.2	"	3.0	2.7
8th	1.5	2.7	3.0	5.4	7.2	"	"	"	3.0	"	2.7	2.1
9th	1.5	2.7	5.4	5.1	7.2	"	"	"	rainy day	"	3.0	2.1
10th	2.1	2.1	4.5	5.1	6.0	3.9	"	"	"	"	3.0	2.1
11th	1.2	2.7	3.9	9.8	7.8	6.3	"	"	"	"	3.0	1.8
12th	1.5	2.7	2.7	8.4	6.3	7.5	"	"	4.2	"	2.4	2.4
13th	1.5	3.0	3.6	6.3	6.3	rainy day	3.9	"	3.3	"	3.0	1.5
14th	1.5	2.4	rainy day	6.6	7.5	"	3.6	"	rainy day	3.9	"	1.5
15th	3	2.1	"	5.7	7.8	3.3	rainy day	"	"	5.1	"	1.2
16th	1.2	2.1	4.8	5.1	7.8	3.3	"	"	"	4.5	"	2.1
17th	3.0	2.4	5.7	6.3	7.2	3.0	"	"	3.0	3.6	"	1.8
18th	3.0	2.1	3.0	5.7	6.9	3.3	"	"	rainy day	4.5	"	1.8
19th	1.8	2.7	3.0	5.4	7.2	rainy day	"	"	"	4.5	"	2.1
20th	1.5	2.4	3.6	9.2	6.6	"	4.2	"	"	4.2	"	2.1
21st	2.7	3.6	rainy day	rainy day	10.1	"	"	"	"	3.6	"	2.1
22nd	2.4	2.7	6.6	"	7.8	"	4.8	rainy day	"	3.0	"	1.8
23rd	1.5	3.0	8.7	4.5	8.1	"	5.1	"	3.6	3.3	"	2.1
24th	2.1	1.8	5.7	4.2	6.9	"	rainy day	"	2.7	3.0	"	2.1
25th	1.8	2.1	4.2	4.8	rainy day	"	3.6	"	3.6	3.9	3.0	1.8
26th	1.5	2.7	3.9	4.8	5.4	"	4.8	"	rainy day	3.0	1.5	2.1
27th	rainy day	3.3	3.9	4.5	6.9	1.5	3.6	3.6	"	3.0	1.5	1.5
28th	3.9	3.3	rainy day	7.2	rainy day	3.3	rainy day	3.0	3.4	2.7	3.0	1.8
29th	5.4	2.7	3.3	9.8	5.4	3.9	4.5	rainy day	2.4	3.3	2.4	1.5
30th	2.7	...	3.6	11.0	6.3	4.2	3.6	"	rainy day	3.0	2.7	1.5
31st	2.7	...	3.3	...	4.8	...	rainy day	"	...	3.0	...	1.5

STATEMENT I—(continued).
Evaporation from a plain water surface at the Agricultural Research Institute, Pusa (1912).

[Date.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	Dec.
1st	mm. 1.8	mm. 1.2	mm. 3.9	mm. 3.6	mm. 5.4	mm. 6.0	mm. rainy day	mm. rainy day	mm. 3.0	mm. rainy day	mm. rainy day	mm. 2.7
2nd	1.5	rainy day	3.9	3.6	6.0	rainy day	"	"	"	3.6	5.4	2.7
3rd	1.8	1.8	3.0	2.7	6.9	3.9	"	6.0	"	3.6	2.4	2.1
4th	1.5	2.7	3.6	3.6	6.3	rainy day	"	rainy day	"	3.6	2.1	1.8
5th	1.5	2.7	4.5	4.8	5.7	5.4	"	4.5	"	4.2	2.7	2.1
6th	1.5	2.7	4.2	7.2	5.7	rainy day	3.6	4.8	"	4.2	2.7	1.8
7th	1.5	2.1	3.9	7.2	5.7	rainy day	rainy day	rainy day	"	3.9	3.0	1.8
8th	1.5	2.4	3.3	6.6	7.2	6.0	rainy day	rainy day	"	3.9	3.0	1.8
9th	1.8	1.5	3.6	5.7	6.0	rainy day	rainy day	"	"	3.3	2.4	2.1
10th	1.5	1.8	3.9	5.1	6.0	4.8	rainy day	"	2.1	3.6	3.0	2.4
11th	1.5	2.4	4.2	6.3	6.9	4.8	"	"	4.2	4.5	3.0	2.1
12th	rainy day	2.4	4.8	4.8	6.6	4.8	"	"	3.9	3.6	2.7	1.8
13th	1.5	2.7	4.5	3.9	5.7	5.4	"	2.4	3.9	4.5	3.0	1.8
14th	1.5	2.7	5.7	4.8	7.2	rainy day	1.8	rainy day	3.9	3.3	3.3	2.4
15th	1.5	2.4	7.5	5.1	4.5	6.0	rainy day	"	3.9	6.0	3.0	1.8
16th	1.8	2.4	5.4	4.5	4.5	6.3	3.9	"	3.6	5.1	3.3	2.1
17th	1.5	2.7	5.1	rainy day	4.8	6.9	3.9	"	3.6	5.1	3.0	2.1
18th	2.1	2.4	4.5	4.2	4.2	6.9	3.9	"	3.6	3.6	2.7	1.2
19th	1.5	2.7	3.0	4.2	4.5	7.2	rainy day	"	4.2	3.6	3.0	1.2
20th	1.8	2.7	5.4	rainy day	4.8	7.5	4.2	"	5.1	3.6	2.4	1.8
21st	1.8	2.7	6.9	rainy day	rainy day	6.6	rainy day	2.1	5.4	3.6	2.7	1.8
22nd	1.8	2.7	4.2	5.1	6.0	rainy day	3.3	2.1	5.1	3.9	rainy day	2.1
23rd	1.5	2.7	3.6	4.8	6.9	rainy day	3.0	rainy day	4.8	4.2	"	1.8
24th	1.8	2.7	3.9	3.6	6.6	5.1	3.0	3.3	3.9	3.9	1.5	1.5
25th	1.8	2.1	3.0	3.0	5.7	rainy day	rainy day	3.3	3.3	3.6	1.8	1.5
26th	2.1	4.5	3.0	5.4	5.7	rainy day	3.6	rainy day	3.3	3.6	2.4	1.8
27th	2.4	4.2	rainy day	5.1	5.7	"	rainy day	3.9	4.2	3.6	2.1	1.8
28th	1.8	3.9	4.2	5.4	6.6	4.5	rainy day	4.2	3.9	3.0	2.4	1.8
29th	1.8	3.3	rainy day	6.0	6.0	rainy day	5.7	rainy day	3.6	3.3	...	1.8
30th	1.2	...	rainy day	...	6.3	...	4.8	3.9	...	3.9	...	1.8
31st	1.2	...	3.9	...	6.3	...	4.8	3.9	...	3.9	...	1.8

STATEMENT II.

Observed rates of evaporation in mm. per 24 hours.

Month.	Pusa, 1911.	Pusa, 1912.	Lyallpur, average of 4 years.	Madras, average of 5 years.
January ...	1·86	1·64	1·83	3·91
February ...	2·58	2·61	2·64	4·67
March ...	4·04	4·30	4·10	5·23
April ...	6·00	4·96	5·78	6·32
May ...	6·87	5·94	9·88	6·91
June ...	4·46	5·80	9·37	7·44
July ...	4·22	3·90	7·76	6·20
August ...	3·37	3·72	6·95	5·89
September ...	3·10	3·95	6·15	4·52
October ...	3·42	3·93	4·90	4·49
November ...	2·95	2·68	3·00	4·01
December ...	1·86	1·91	1·98	3·86

Owing to the circumstance already explained, the evaporation at Pusa is only known for dry days, and hence the total annual evaporation can only be estimated by the aid of the formula which is subsequently discussed. In order to calculate, at least approximately, the total evaporation at Pusa, it has been assumed for wet days, that this is nominal for days on which more than '5" of rain fell, whereas on the remaining wet days the quantity is that which may be calculated by my formula from the meteorological data. The total annual evaporation at Pusa in comparison with Lyallpur and Madras may then be thus compared (centimeters).

	PUSA.				Lyallpur.	Madras.
	No. of days.	1911.	No. of days.	1912.		
Observed dry days ...	280	104·5	303	111·8		
Calculated for wet days ...	59	20·9	39	14·6		
TOTAL ...		125·4		126·4	196·2	193·2
		4·12ft		4·18ft.	6·42 ft.	6·34 ft.

The similarity of the amounts of evaporated water at Lyallpur and at Madras respectively is naturally merely accidental.

The calculation of evaporation from a plain water surface.—Many attempts have been made and much time has been spent in the evolution of a mathematical formula which will express

the amount of water which evaporates from a plain water surface. Thus we have :—

1. Russell's

$$E = \frac{\text{inches}}{\text{month}} = \frac{30}{B} [43.88 (e_i - e_d) + 1.96e_i]$$

in which, E = evaporation

e_i = vapour pressure at temperature of wet bulb thermometer

e_d = vapour pressure at dew point temperature.

2. Abbassia's

$$E = \frac{\text{mm.}}{\text{hour}} = .0122 (e_w - e_d) + .00029 (e_w - e_d)v$$

3. Fitzgerald's

$$E = \frac{\text{mm.}}{\text{hour}} = .0166 (e_w - e_d) + .000783 (e_w - e_d)v$$

4. Carpenter's

$$E = \frac{\text{mm.}}{\text{hour}} = .0161 (e_w - e_d) + .0000895 (e_w - e_d)v$$

5. Stelling's

$$E = \frac{\text{mm.}}{\text{hour}} = .0351 (e_w - e_d) + .00044 (e_w - e_d)v$$

where in the last four of which,

e_w = vapour pressure at the water surface temperature

e_d = vapour pressure at the dew point temperature

v = wind velocity in metres per second.

F. H. Bigelow* in an article compares these formulæ under stated circumstances and since they yield very widely different results, he concludes that none is reliable. Another formula of Russell's is :— $A p_w + B (p_w - p_a)$

in which p_w = vapour tension corresponding to the wet bulb thermometer

p_a = vapour tension corresponding to the dew point.

$$A = 1.96$$

$$B = 43.9$$

This formula also seems to yield very incorrect results ; that in one quoted example being only two-thirds of the directly ascertained quantity.

* U. S. A. Monthly Weather Review, July 1907.

In any case each of these formulæ depends on the possession of correct information regarding the aqueous tension of the atmosphere as well as generally the wind velocity. But there is nothing more difficult to obtain than a continuous record of vapour tension and it is very much simpler to determine the evaporation directly. In fact, a formula to be of any practical utility must depend simply on the usual meteorological data of the country, namely, mean temperature, humidity and wind velocity.

After plotting the results of evaporation at Pusa as shown in Charts I & II an attempt was made to derive an empirical formula which might meet the case. It was assumed that a formula of the type $E = t^x D^y W^z$ would satisfy the conditions in which

E = evaporation ;

t = the temperature of the atmosphere ;

D = the dryness of the atmosphere ;

W = the wind velocity.

Regarding D , it is the difference between 100 per cent. and the relative humidity. It seemed probable that if, instead of relative humidity, the difference between 100 per cent. and this figure were used, the effect of this factor would be more pronounced. For example, there is a greater relative difference between 20 per cent. and 10 per cent. of "dryness" than between 80 per cent. and 90 per cent. humidity.

For the end in view the mean data of short periods during December, March and April—about six days each—when the atmospheric conditions were very uniform, were set out. The values of the indices x , y , z were then obtained by the method of least squares, which yielded:—

$$x = -\cdot11786$$

$$y = +\cdot44366$$

$$z = +\cdot215994$$

$$E = \text{mm. per 24 hours.}$$

This equation then yielded values of evaporation for Pusa which agree well with the evaporimeter record. But on applying it to

Punjab data, it proved highly defective. Moreover, the negative value of x rendered it from the first unlikely to be generally useful.

Another formula which seems to be more generally useful was obtained by (a) plotting the logs of the three factors, temperature, dryness and wind velocity, against the log of evaporation, from which values of the type

$$a (\log t - b)$$

were obtained, which proved a suitable basis to work from, and then (b) by a series of approximations the following more accurate values were obtained :—

$$E = (\text{mm. per 24 hrs.}) = 2.0 (\log t - 1.74) \\ + .33 (\log D - 1.00) + .36 (\log W - .125)$$

in which

t = mean temperature °F. for day ;

D = $100 - 8$ A.M. humidity ;

W = mean wind velocity for day ;

common logs were naturally employed.

This formula has yielded the results which are set out in Statements Nos. III, IV & V.

It will be seen that for the majority of months the calculated evaporation agrees fairly well with the actual ; there are 14 cases among the 48 in which the divergence exceeds about 10 per cent. and 5 cases in which it exceeds 20 per cent. Some of these cancel one another during the year. Thus the following shows the annual evaporation, in *centimetres* at the three stations :—

		Actual cm.	Calculated cm.	Error.
Pusa 1911	...	* 104.5	99.7	5%
Pusa 1912	...	* 111.8	109.1	2%
Lyllpur	...	196.2	184.8	6%
Madras	...	193.2	179.5	7%

* Dry days only.

Hence for the approximate estimation of the annual evaporation from the ordinary meteorological data the formula may be relied upon. On the other hand, the error which may occur in individual estimates may be serious.

Although my formula is a purely empirical one, it is apparently a considerable advance on any of those previously used. At the same time there is no doubt that for an accurate record of evaporation it is much better to ascertain this directly than to rely on the formula, and it is also simpler to do so than to estimate specially the several meteorological factors.

STATEMENT III.

Evaporation from a plain water surface at PUSA as experimentally determined, and calculated from meteorological data respectively.

MONTH.	Mean temperature °F	Mean humidity 8 A.M.	Dryness.	Mean wind velocity miles per hour.	EVAPORATION.	
					Found mm. per 24 hours.	Calculated mm. per 24 hours.
1911						
January	62.7	90.6	9.4	3.20	1.86	1.75
February	64.1	78.75	21.25	2.78	2.58	2.28
March	72.5	62.24	37.76	4.32	4.04	4.14
April	83.8	57.0	43.0	4.83	6.00	6.01
May	87.9	69.25	30.75	6.99	6.87	6.75
June	88.0	70.0	30.0	4.74	4.46	5.84
July	86.7	82.3	17.7	4.23	4.22	4.56
August	85.1	89.2	10.8	2.75	3.37	3.19
September	84.4	85.5	14.5	3.05	3.10	3.60
October	78.8	85.1	14.9	1.84	3.42	2.64
November	69.1	86.5	13.5	1.74	2.95	1.94
December	60.7	91.9	8.1	2.24	1.86	1.34
1912						
January	61.7	92.3	7.7	2.89	1.64	1.53
February	67.0	82.5	17.5	2.97	2.61	2.39
March	73.4	57.7	42.3	4.90	4.30	4.61
April	80.4	66.7	33.3	5.60	4.90	5.12
May	86.9	69.3	30.7	5.36	5.94	6.00
June	88.6	76.1	23.9	5.04	5.80	5.61
July	85.5	85.9	14.1	6.02	3.90	4.67
August	85.0	84.5	15.5	4.48	3.72	4.28
September	84.1	78.5	21.5	2.80	3.95	3.95
October	79.3	75.7	24.3	1.74	3.93	3.08
November	69.1	82.2	17.8	2.42	2.68	2.37
December	61.8	89.8	10.2	1.96	1.91	1.46

NOTE.—These data refer to dry days only.

STATEMENT IV.

Evaporation from plain water surface at Lyallpur as experimentally determined and calculated from meteorological data respectively.

MONTH.	Mean temperature °F.	Mean humidity 8 A.M.	Dryness.	Mean wind velocity miles per hour.	EVAPORATION.		
					Found.		Calculated.
					ft. per hour.	mm. per 24 hours.	mm. per 24 hours.
January...	54	75	25	2.5	.00025	1.83	1.76
February...	59	70	30	3.5	.00036	2.64	2.35
March ..	70.5	60	40	6.0	.00056	4.10	4.49
April ...	81	45	55	4.0	.00079	5.78	5.70
May ...	91	40	60	6.0	.00135	9.88	8.56
June ...	96	47	53	6.0	.00128	9.37	9.14
July ...	92.5	75	25	6.0	.00106	7.76	6.61
August ...	90	70	30	5.0	.00095	6.95	6.83
September...	87	60	40	5.0	.00084	6.15	6.40
October...	78	50	50	2.0	.00067	4.90	3.99
November...	66	55	45	2.5	.00041	3.00	2.99
December...	56	65	35	2.0	.00027	1.98	1.82

NOTE.—The meteorological data for Lyallpur were taken from Eliot's meteorological atlas. The record of evaporation is that published by the Public Works Department, Irrigation Branch, and is an average of 4 years, 1906-1910.

STATEMENT V.

Evaporation from plain water surface at Madras as experimentally determined and calculated from meteorological data respectively.

MONTH.	Mean temperature °F.	Mean humidity 8 A.M.	Dryness.	Mean wind velocity miles per hour.	EVAPORATION.		
					Found.		Calculated.
					Inches per 24 hours.	mm. per 24 hours.	mm. per 24 hours.
January ...	74.6	82.6	17.4	4.48	.154	3.91	3.48
February...	78.9	92.0	8.0	3.69	.184	4.67	2.76
March ...	83.0	78.1	21.9	5.74	.206	5.23	5.01
April ...	85.1	74.3	25.7	4.97	.249	6.32	5.27
May ...	91.4	64.6	35.4	6.32	.272	6.91	7.38
June ...	92.4	62.7	37.3	6.53	.293	7.44	7.77
July ...	88.3	68.8	31.2	4.87	.244	6.20	6.01
August ...	86.9	75.3	24.7	4.55	.232	5.89	5.26
September...	86.5	77.7	22.3	3.93	.178	4.52	4.65
October...	83.0	82.7	17.3	3.45	.177	4.49	3.86
November...	78.9	83.3	16.7	4.33	.158	4.01	3.74
December...	75.8	82.8	17.2	5.00	.152	3.86	3.67

NOTE.—The meteorological data for Madras are taken from the India Daily Weather Report. The record of evaporation is the average of 5 years' records, 1898 to 1903, which were communicated by the Meteorological Department.

